Prošireni sažetak / Extended abstract

Left ventricular 4D imaging with low radiation dose through optimised interphase registration of rotational angiography images

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Objectives: VT ablations could benefit from dynamic 3D (i.e. 4D) visualisation of the left ventricle (LV) as roadmap for anatomy-guided procedures, e.g. by means of rotational angiography (3DRA). To limit radiation burden, low-dose, noisy 3DRA image datasets have to be used. Our aim was to develop an algorithm combining information of several cardiac phases to filter out noise, enabling accurate semi-automatic segmentation (SAS) and generation of multi-phase segmentation surfaces.

Methods and Results: We explored non-rigid interphase registration (IPR) using image warping and subsequent image averaging of 4 cardiac phases in low-dose 3DRA images from 5 porcine experiments, acquired with a novel protocol of slow atrial pacing. IPR parameter settings were optimised against manual delineations of the LVs using a score (Q) composed of standardised similarity measures. SAS was done for varying voxel intensity thresholds (ISO). **Figure A** shows a 4D posterior view sequence of 4 LV phases constructed with and without IPR, after SAS at ISO = 0 relative to optimal ISO. Relevant structures are the apex (1), LV inflow (2), LV outflow tract (3) and posterior papillary muscle (4). Distances to the manual delineations were reduced to 3 mm for 95.6 ± 2,7% of model surfaces (d3mm) at optimal ISO with IPR. Post-SAS IPR and non-IPR models were compared using 3 quality measures (Q; d3mm and Hausdorff Distance [HD, reflecting maximum error]). Improved quality was proven by significant increases in d3mm (illustrated in **Figure B** for the experiment of Figure A) and Q irrespective of ISO (mean increase at optimal ISO was 7.75% (95%CI 4.60-10.90, p<0.0001) for d3mm and 7.57% (95%CI 4.65-10.50, p < 0.0001) for Q). HD decreased significantly (-21.35%; 95%CI -18.61—24.10, p<0.0001). 4D model generating time was ±11.5min with IPR vs. ±22min without.

Figure A. *Post-segmentation 4D model sequence built of four cardiac phases with (blue) and without (green) use of IPR is shown for one experiment at optimal non-IPR ISO (relative ISO = 0). The four phases in the non-IPR sequence were all segmented directly from the reconstructed 3DRA images, without prior application of IPR. The significant difference in image quality can be observed. Anatomical structures that can be seen in this view of the posterior wall of the left ventricle are the apex (1), the LV inflow tract (2), the LV outflow tract (3) and the posterior papillary muscle (4).*

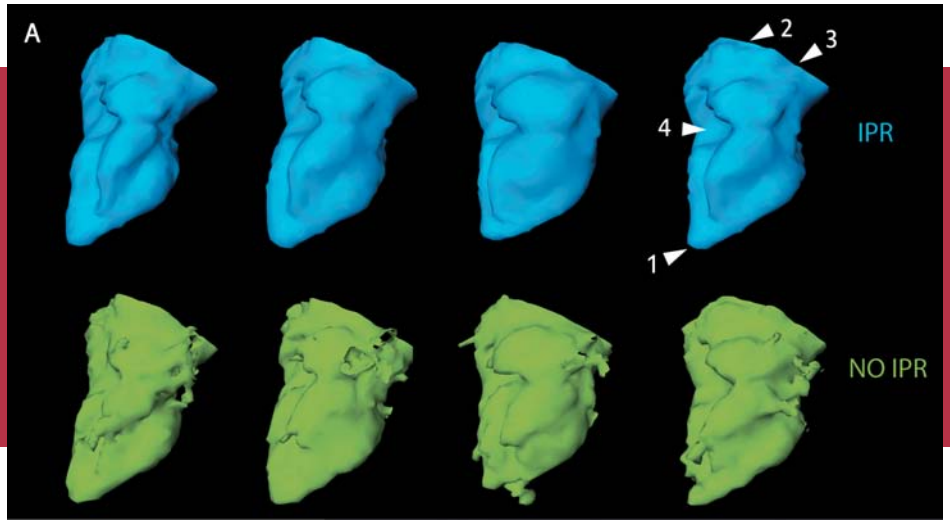
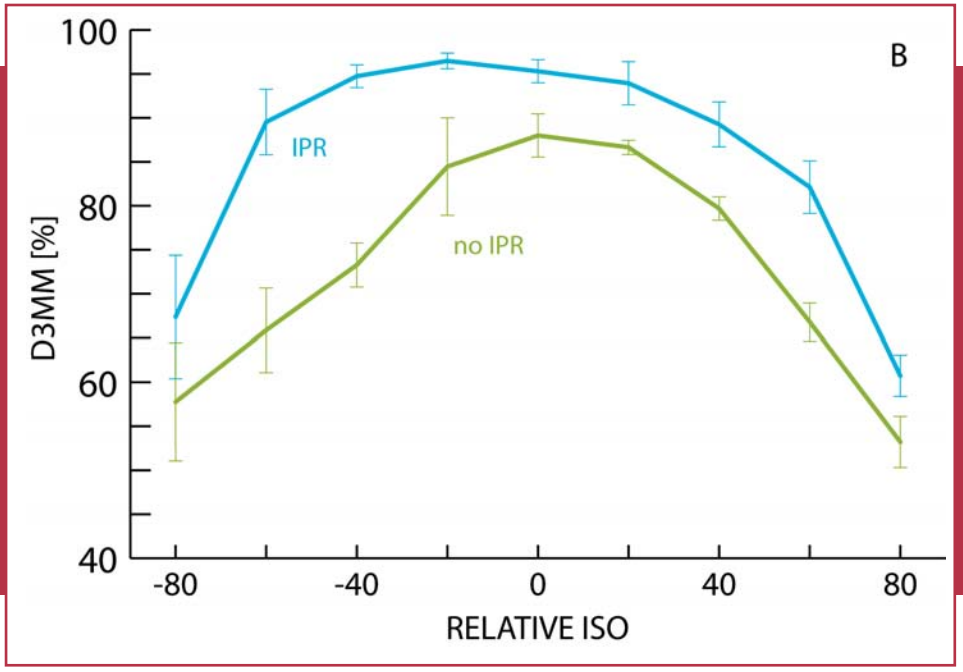


Figure B. *Distance measure indicating the percentage of distances from the post-segmentation model surface to the ground truth surface (manual delineations of the left ventricles) 3 mm (d3mm), averaged over all 4 phases (mean ± SD), in both IPR (blue) and non-IPR (green) for the relevant relative ISO range in the experiment shown in Figure A.*



Conclusions: Generating 4D LV models is feasible, with clinically useful accuracy, using a novel image acquisition protocol and non-rigid IPR to reduce image noise and speed up 4D image generation. Due to the use of low dose acquisition protocols, radiation dose can be kept at a clinically acceptable low level. By using slow atrial pacing, the risk of inducing unwanted ventricular tachy-arrhythmias is minimised. These findings open the perspective of realising a 4D image sequence for more accurate integration with electro-anatomical mapping systems or per-procedural fluoroscopy to facilitate ablation in locations with high degrees of movement (like the LV).

KEYWORDS: imaging, catheter ablation, 3D rotational angiography, low radiation dose, electro-anatomical mapping.

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